planes) were recorded at baseline and 12 week follow up visits from each participant while walking on a treadmill at a self-selected comfortable speed using a portable 3D knee kinematic analyser (KneeKGTM).
Paired T-test was performed to compare the baseline and 12 week follow up WT, TUG and KKG measures. Multiple regression analyses were performed to examine the association between changes in knee kinematic and health outcome measures in knee OA participants following the 12 weeks of the OACCP.
Results: 102 knees from 72 persons with knee OA were assessed at the initial visit and 62 knees from 46 participants were assessed 12 weeks later after enrolment in the OACCP program. 66% were female; their mean age was 70.1 years, mean BMI of 28.8kg/m2.
Results of the paired T-test showed significant improvement in most of the health outcome measures at the 12 weeks follow up assessment (Table 1). There were some significant changes in kinematic measures in all three planes of movements.

Table 1
Demographics, paired *t*-test of baseline and 12 weeks follow up measures

	Baseline	Follow-up	Paired *t*-test P
Number of patients	79	46	
Number of knees	102	62	
Sex (female)	47 (59.5%)	30 (65.2%)	
Age, mean (SD)	68.6 (8.6)	69.9(8.3)	
Weight (kg)	81.2 (15.8)	79.7 (15.5)	0.000
BMI, mean (SD)	29.5 (5.5)	28.9 (5.3)	0.000
TUG (sec), mean (SD)	9.7 (3.4)	8.3 (2.7)	0.000
KOOS factors (0-100), mean (SD)			
Pain	46.9 (20.4)	55.2 (17.3)	0.000
Symptoms	47.5 (18.2)	52.5 (16.5)	0.006
ADL	51.3 (20.7)	58.7 (18.9)	0.000
Sport/recreation	51.0 (20.4)	58.8 (18.3)	0.000

Table 2
Association of knee kinematic change with change in KOOS measures

	ΔKOOS Pain		ΔKOOS sport/recreation	
	B (CI)	P	B (CI)	P
Change in external/ internal rotation Range of motion	-1.33 (-2.56 – -0.08)	0.038	-1.22 (-2.37 – -0.07)	0.038

*Data presented as regression coefficients (B). Change in KOOS factors entered as dependent variables, regression models adjusted for age, gender, BMI and baseline KOOS measures.

Table 3
Association of kinematic change with change in weight and TUG

	Weight		TUG	
	B (CI)	*P*	B (CI)	*P*
Flexion / Extension				
Knee flexum at initial contact	0.66 (0.13 – 1.19)	0.016	0.92 (-0.04 – 1.87)	0.059
Average angle at loading phase	0.52 (0.03 – 1.01)	0.038	1.01 (0.14 – 1.87)	0.023
Average angle at Push off	0.70 (0.12 – 1.29)	0.018	0.62 (-0.44 – 1.70)	0.246
Average angle at mid stance phase	0.31 (-0.16 – 0.79)	0.194	1.37 (0.59 – 2.14)	0.001
Abduction / adduction				
Average Angle at Initial Contact	-0.19 (-0.70 – 0.32)	0.454	-0.87 (-1.72 – -0.02)	0.044
Average angle atloading phase	-0.17 (-0.71 – 0.36)	0.516	-0.97 (-1.84 – -0.09)	0.031
Average angle at push off	-0.20 (-0.72 – 0.32)	0.448	-0.93 (-1.80 – -0.06)	0.037
Average angle at mid stance phase	-0.22 (-0.75 – 0.32)	0.424	-0.95 (-1.81 – -0.08)	0.032

Data presented as regression coefficients (B). Change in KKG measures were entered as dependent variables, regression models adjusted for age, gender, baseline BMI and KKG measures.

Changes in the range of motion (ROM) in the transverse plane were negatively related to the improvements in KOOS Pain and Sport/Recreation scores (Table2). Meaning, a decrease in the external/internal rotation ROM at the follow up that potentially indicated a “more stable” knee, is associated with improvements in pain and function.
Changes in knee kinematics were also associated with changes in weight and TUG (Table 3). More specifically, while changes in sagittal plane (such as less knee flexion at the initial contact of the gait cycle, possibly an indication of a lesser “stiff knee”) were mostly responsive to the weight loss, changes in the frontal plane kinematics (slightly more varus) showed stronger association with the improvement in TUG. One could hypothesize that for patients with faster TUG time, there is less control of the frontal plane kinematics.
Conclusion: Results suggest that decreasing knee transverse plane ROM in the treatment plan could help reduce pain level and improve function during activities. Knee biomechanics is also strongly associated with weight loss and improvement in pain and TUG following 12 weeks of OA rehabilitation program. This suggests that biomechanical improvement can lead to functional and clinical outcome gains with targeted treatment.

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GAIT, SYMPTOMS AND FUNCTION IN PATIENTS WITH MILD TO MODERATE HIP OSTEOARTHRITIS: 6-7 YEAR FOLLOW-UP

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Purpose: Existing studies concerning biomechanics in hip osteoarthritis have primarily included patients in a severe stage of disease. Therefore, current knowledge on the natural history and progression of hip osteoarthritis from a biomechanical perspective is sparse, and prospective studies on hip osteoarthritis patients who do not undergo total hip replacement are needed. The aims of this study were firstly to compare hip- and knee joint excursion and moments during the stance phase of gait between hip osteoarthritis patients with mild to moderate symptoms who later underwent total hip replacement, and patients who remained non-operated; and secondly to evaluate alterations in gait, minimum joint space or physical function among the non-operated patients at a 6-7 year follow-up.
Methods: Fourty-three subjects were included in the material. Inclusion criteria were age between 40 and 80 years, radiographic osteoarthritis defined from Danielson’s criteria, and a Harris Hip Score between 60 and 95. Patients with knee pain and/or knee osteoarthritis were excluded. Gait analyses both at baseline and at 6-7 year follow-up were conducted utilizing a Qualisys Pro-Reflex motion analysis system with 8 cameras, synchronized with two AMTI LG6 force plates. Four selected events during stance phase were identified for analysis: Initial contact, mid-stance, peak hip extension angle, and toe-off. Minimal joint space was measured with standardized postero-anterior digital pelvic radiographs centered on the symphysis. In addition, we included self-reported pain, stiffness and function from the Western Ontario and McMaster Universities Arthritis Index (WOMAC), hip range of motion and the 6-minute walk test. Gait characteristics in patients who later underwent total hip replacement and patients who remained non-operated were compared at baseline with independent t-test and Mann-Whitney U-test. For the non-operated patients, paired samples t-test and Wilcoxons Sign Rank Test were conducted to compare data at baseline and at 6-7 year follow-up. Statistical significance was set as $p<0.05$.
Results: To our knowledge, this is the first study to explore long-term gait characteristics and functional status in hip OA subjects who have not undergone total hip replacement. At the 6-7 year follow-up, 31 of the patients (19 females/12 males; mean (SD) age 58.0 (9.48) years) had undergone total hip replacement surgery, whereas 12 patients (10 females/2 males; mean (SD) age 59.8 (7.06) years) were still non-operated. At baseline, statistically significant differences were found between the non-operated subjects and those who later underwent total hip replacement. The non-operated patients had lower BMI ($p =$

0.033), larger minimal joint space ($p<0.001$), and superior self-reported WOMAC function ($p = 0.019$) and stiffness ($p = 0.019$). During gait, the non-operated patients had larger hip- and knee joint excursion and a larger hip flexion moment during the latter 50% of stance (p-values 0.003 to 0.015). No differences were found from baseline to follow-up in gait characteristics, minimal joint space, 6-meter walk test, or overall function at the 6-7 year follow-up of the non-operated patients. Self-reported pain assessed from the WOMAC was significantly improved ($p = 0.024$).

Conclusions: Even if all patients were classified as having mild to moderate symptoms at inclusion, we found significant baseline differences both in gait and function between the patients who later underwent total hip replacement and those who were still non-operated at the 6-7 year follow-up. The non-operated patients revealed no signs of disease progression at follow-up. Joint excursion and moments were maintained, and neither the minimal joint space, 6-meter walk test, overall hip range of motion, or self-reported WOMAC function, stiffness or pain deteriorated.

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KNEE JOINT STIFFNESS AND ITS RELATIONSHIP WITH SEVERITY OF RADIOGRAPHIC OSTEOARTHRITIS, PAIN AND SELF-REPORTED STIFFNESS

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Purpose: Joint stiffness is a common symptom of knee osteoarthritis (OA) but often only evaluated using self-reported questionnaires. The passive pendulum test is a biomechanical laboratory test that has been used to measure the stiffness and damping co-efficients in the knee which are related to the biomechanical properties of the tissues making up the joint. The aims of this study were to [1] determine if stiffness and damping co-efficients differ between persons with normal knees (controls), knee pain (KP), radiographic knee OA (ROA) and symptomatic knee OA (SOA); [2] examine the relationships between radiographic severity, pain severity, self-reported stiffness and the lab based measures, and [3] explore how anthropometric measures, pain severity, and radiographic variables contribute to the overall variance of the biomechanically assessed stiffness co-efficient.

Methods: 243 community participants were recruited and divided into 4 groups based on the presence or absence of moderate knee pain and ROA ($\geq$ grade 2 Kellgren & Lawrence). Stiffness and damping co-efficients were derived from the angular motion of the knee during the passive pendulum test using a motion analysis system (Coda). X-rays were graded using the Nottingham Logically derived Line Drawing Atlas. A 100 mm VAS was used to assess pain severity and the Western Ontario and MacMasters Osteoarthritis Index was used to assess self-reported pain, stiffness and function.

Results: 243 participants were recruited with 157 (65%) women and 86 (35%) men. Mean age was 70.3 years (SD 8.9). 90 participants had normal pain-free knees, 59 had KP only, 32 had ROA and 62 had SOA. Over a third of participants (89) were unable to successfully perform the passive pendulum test. The reliability of the test in those who could perform it was high (ICC = 0.85 95% CI (0.52 – 0.96) for damping co-efficient and ICC = 0.96 95% CI (0.85-0.99) for stiffness co-efficient).

The mean stiffness co-efficient was significantly higher in the SOA group compared to controls (mean difference = 2.91 Nm/rad $p = 0.04$) but not between other groups. We found no significant differences between groups for the mean damping co-efficient. A weak correlation was observed between radiographic severity and the stiffness co-efficient ($r = 0.19$, $p = 0.2$). Pain severity using the VAS and WOMAC scores showed positive correlations with the stiffness co-efficient ($r = 0.3$, $p<0.01$ and $r = 0.2$, $p<0.01$ respectively) but not with damping co-efficients. WOMAC stiffness was correlated with stiffness co-efficients ($r = 0.3$, $p<0.01$) and was stronger when examined in those participants with SOA ($r = 0.4$, $p<0.01$). We also found that WOMAC stiffness was strongly correlated with pain VAS scores ($r = 0.80$, $p<0.01$).

A multiple regression was run to predict stiffness co-efficients from age, gender, body mass index (BMI) pain VAS, radiographic scores and WOMAC stiffness scores ($F(6,147) = 58.2$, $p<0.001$, $R2 = .0.70$) but only gender and BMI were significantly associated ($p<0.001$).

Conclusions: Stiffness co-efficients were significantly higher in those with SOA compared to those with normal knees and showed modest correlations with radiographic severity, pain severity and self-reported stiffness. Consistent with previous research we found that BMI and gender were significant predictors of stiffness co-efficients but that additional variance could not be explained by radiographic or pain severity or by self-reported stiffness. Further research is needed to consider the validity of the passive pendulum test, particularly in older persons who may find it difficult to perform. The lack of association between the biomechanical co-efficients and radiographic severity suggests that other neuro-muscular variables may have a greater role to play in biomechanically assessed joint stiffness.

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CENTER OF PLANTAR PRESSURE CAN PREDICT CHANGES IN TIBIOFEMORAL CONTACT LOAD

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Purpose: Biomechanical treatments for individuals with medial compartment knee osteoarthritis (OA) often target the knee adduction moment (KAM). The peak KAM, which has been implicated in both OA severity [1] and progression [2], is altered during walking using shoe adaptations or gait modifications such as “medial thrust” gait;[3] however, individuals vary in their load response. Successful KAM reductions are frequently attributed to shifts in center of plantar pressures (COP) although a clear relationship between knee loads and foot pressure has not been demonstrated. Establishing such a relationship would profoundly increase the biomechanical treatment options for OA. Therefore, the aim of this cross-sectional study is to determine if COP is consistently medialized when peak KAM is reduced. Since other moments can contribute to increase or decrease knee loading, the sagittal and transverse planes were investigated as well. A definitive relationship of COP with KAM would support the use of pressure distribution as an indirect marker of load across the tibiofemoral joint (TFJ).

Methods: 16 healthy subjects (26.9 $\pm$ years, 9M,7F) completed 5 barefoot walking trials each of normal gait and medial thrust gait. Left leg data were analyzed and reported. Lower limb kinematics were obtained using 12 optoelectric cameras (Qualysis, Gothenberg, Sweden) and 28 reflective markers on bony landmarks. For simultaneous COP and 3-D ground reaction force acquisition, a pressure platform (Emed, Novel, Munich, Germany) was mounted onto a force plate (Bertec, Columbus, OH) and the stacked assembly was leveled with the walkway. All capture systems were run at 100 Hz to allow for accurate synchronization of stance phase, knee moments, and plantar pressures. COP was quantified by determining the Medial to Lateral Pressure Index (MLPI) (Figure 1). Differences in COP between normal and thrust gait were calculated and compared to the corresponding changes in KAM, sagittal and transverse plane moments. Pearson Correlation and linear regression analysis were used to compare the change in each peak KAM and the corresponding change in MLPI.

Results: During the first half of stance, a shift in of COP was highly correlated with a change in first peak KAM (Table 1, Figure 2). COP and KAM demonstrated a lower but significant correlation during the 2nd half of stance. The flexion moment was the only other moment which correlated with MLPI (Table 1). A change of MLPI during each half of stance was best predicted by the corresponding peak KAM; adding knee flexion moment walking speed, gender, and age did not enter the forward regression model, although speed influenced the 2nd peak KAM ($r = 0.579$, $p = 0.019$).

Conclusions: This study establishes that plantar pressure measurements can be used to indirectly assess the response in load distribution across the TFJ with medial thrust gait. 100% of subjects who medialized their plantar pressures in the first half of stance also reduced their first peak KAM. Both sagittal and transverse plane moments increased with medial thrust walking which may diminish the therapeutic benefits from a reduced KAM, however the impact of these moments on the progression of medial compartment OA is not well established. While these findings have been derived from medial thrust gait, further testing with other gait retraining methods and biomechanical interventions that do not directly interfere with a shoe-pressure detecting insole-foot interface should yield similar results. As such, a cost-effective pressure detection device may be suitable for detecting change in load across the TFJ as a result of a biomechanical gait intervention.